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EXHAUST MUFFLER-CLEANER, PARTICULARLY FOR INTERNAL COMBUSTION ENGINES

Luigi Carboni

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EXHAUST MUFFLER-CLEANER, PARTICULARLY FOR INTERNAL COMBUSTION ENGINES

[Silencieux-epurateur d'echappement, specialement pour des moteurs a combustion interne]

Inventor:	Luigi Carboni
Applicant:	Luigi Carboni, Pier Antonio Cornaglia

The present invention relates to an exhaust muffler-cleaner, particularly for internal combustion engines, of the type in which the exhaust gases not only are regularized in their flow conditions in order to reduce noise but are also subjected to afterburning for the purpose of eliminating their unburned parts, and to catalytic action aiming to eliminate the harmful substances. /1*

It is known that the pollution produced by combustion, and particularly by that taking place inside internal combustion engines, is not due to the products of regular combustion of hydrocarbons (carbon dioxide and steam) but rather is due to the products derived from incomplete combustion (unburned hydrocarbons and carbon monoxide), to the products of combustion of impurities (particularly sulfur compounds) and to the products derived from

* [Numbers in right margin indicate pagination of the original text.]

collateral chemical reactions (among which the nitrogen oxides are particularly harmful). For these reasons, much research has been done with the aim of producing exhaust gas cleaning devices capable of eliminating said contaminating products, and particularly valuable results have been obtained in particular based on previous studies performed by the same author of the present invention, through the combination of afterburning action and catalytic action, in a device which acts simultaneously as muffler and cleaner and which is suitable moreover for providing an auxiliary thrust which is useful for propulsion. However, these devices pose certain problems with no easy productive solution, the first of which is the production of a simple and sure means of combustion, capable of initiating and maintaining the afterburning reaction in spite of the low flammability of the exhaust gas mixtures in which the unburned products to be burned are present in a very dilute state.

The difficulties encountered in cleaning exhaust gases produced by gaseous fuels or /2
gasoline are further multiplied in the cleaning of the exhaust gases produced by gas-oil or by fuel oils, particularly because of the high content of impurities contained in them. It has consequently not been possible up to now to satisfactorily clean the exhaust of Diesel engines.

The present invention aims to give a satisfactory solution to the problems posed up to now by the muffler-cleaners of the type mentioned in the preamble.

This goal is reached, according to the present invention, by the fact that the device mainly includes a first intake for the exhaust gases to be treated, a second intake with nonreturn valves for additional air, said second intake being arranged in the form of a ring around the first intake, an axial suction fan arranged so as to act with its central portion in association with said first intake, and with its peripheral portion in association with said second intake, an afterburning chamber arranged so as to receive the confluence of the flows coming from said first and second intakes, a burner arranged in said afterburning chamber, said burner being in the form of a hollow body with intake and outlet openings and containing thermal elements electrically heated to the temperature of light emission, a set of catalytic elements arranged downstream from said afterburning chamber, and a flow adaptor; as well as a thermally and acoustically insulated casing whose internal walls are aerodynamically shaped so as to follow the transformations of the gases passing through the different parts of the device.

Due to these characteristics, the exhaust gases to be cleaned, generally coming from an internal combustion engine, which are routed towards said first intake, actuate the fan, giving rise to suction of additional air through said second intake, and the two streams arrive at the afterburning chamber radially stratified, with exterior layers formed mainly by fresh air and /3
interior layers formed mainly by hot exhaust gases. A part of the latter penetrates into the burner where, because of the combined effect of thermal and light emissions of the thermal elements, an endothermic dissociation of the carbon dioxide and other compounds takes place. It has been

observed that this phenomenon is greatly promoted by the photochemical effect exerted by the incandescent thermal elements. The phenomenon, which takes place in an intense manner in the burner, is verified partially also in the surrounding medium when, under operating conditions, the whole burner reaches a temperature of light emission. The part of the exhaust gases thus treated then flows through the outlet openings of the burner, being mixed with the rest of the gases in the afterburning chamber, where the exothermic recombination of the carbon dioxide and other compounds is carried out, with a consequent increase of the temperature and an effective igniting of the unburned substances and of the carbon monoxide, which are then burned with the help of the oxygen contained in the additional air. In this way, an almost complete elimination of the unburned substances and of the carbon monoxide is obtained. The hot gases leaving the afterburning chamber then go into the set of catalytic elements, in which catalytic cracking affects the residues of the unburned substances, and the carbon monoxide is oxidized, while the nitrogen oxides and certain other substances are decomposed and reduced to noncontaminating elements. Finally, through the exhaust pipe adaptor, the gases are discharged with recovery of at least a part of their kinetic energy in the form of usable mechanical thrust.

When the device is intended for a vehicle, said second intake is advantageously arranged so as to be subjected to the action of a stagnation pressure produced by the wind from the travel of the vehicle. In this way, suction of additional air is promoted, and under particular conditions, it can be the additional air itself that actuates the fan, in that case exerting a suction action on the exhaust of the engine to which the device is applied. /4

The suction fan is calculated to exert its maximum action at medium speed (for example, at 60% of the maximum speed) of the engine for which the device is intended. This gives rise to the greatest practical yield, in consideration of the fact that the maximum speeds are only rarely used.

Preferably, said burner is in the form of a body made of stainless steel containing nickel. In this way, the catalytic properties of this metal are used to make the described effects more intense.

Moreover, said set of catalytic elements is preferably made up of a series of alternating disks and rings formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy. Catalytic elements of this type, of reasonable cost, have a long service life and join a useful filtration effect with their catalytic action. The latter, different from that of the platinum-containing catalyst ordinarily used, is not limited to action on the nitrogen oxides, but acts in particular on the sulfur compounds, giving rise to solid residues which consequently can be separated easily.

Preferably, installed downstream from the set of catalytic elements is a nondissipative noise dampening component, formed by a spiral perforated metallic sheet. Such a component

regularizes the exiting stream, attenuating its vibrations, without offering any appreciable resistance to the stream itself.

It is advantageously provided that the flow adaptor is delimited by two elements mutually fitting together, applied towards one another by elastic components, with a pressure corresponding to the action exerted by the exhaust gases under medium operating conditions. In this way, under operating conditions at speeds higher than medium speed, said two elements delimiting the flow adaptor are moved apart from one another by the pressure of the gases, and /5
they then offer a larger cross section for the flow, thus preventing choking which under these conditions is verified in the usual mufflers and which leads to a reduction of the yield.

These characteristics of the invention and others will emerge more clearly from the following description of an embodiment given as a nonlimiting example and illustrated diagrammatically in the appended drawings in which:

Figure 1 represents, on a reduced scale, a longitudinal section of an exhaust muffler-cleaner according to the present invention;

Figure 2 is a view, considered according to arrow II of Figure 1, of the second intake provided with a nonreturn valve;

Figure 3 represents a section made according to broken line III-III of Figure 1, and it shows the suction fan in particular;

Figure 4 represents a section made according to line IV-IV of Figure 1, and it shows the burner in particular;

Figure 5 is an axial view of the device on the flow side, considered according to arrow V of Figure 1.

Indicated by the number 0 in Figure 1 is a terminal section of an exhaust pipe, for example, of the endothermic engine of a vehicle, to which the muffler-cleaner device according to the invention is applied. The shape and dimensions of this device are similar to those of an ordinary exhaust muffler, and its installation consequently entails no particular problem. Section 0 of the exhaust pie is inserted and attached in tubular element 1 constituting the first intake of the device. Arranged coaxially around this first intake 1 is tubular element 2 of greater diameter, constituting the second intake intended for the passage of additional air, said second intake, if applicable, will be arranged so that it is caught by the wind from the travel of the vehicle so that a stagnation pressure can act on it. Arranged in tubular element 2 is valve plate 3 which /6
cooperates with lamellar valve segments 4 protected by curved posterior shoulders 5, in order to form a nonreturn valve allowing the suction of air but not its accidental back flow. This suction unit is protected exteriorly by shell 6 of perforated sheet metal or metallic netting.

Arranged behind the concentric openings of intake elements 1 and 2 is helical fan 7 with longitudinal axis, with five blades in the present case, whose shaft freely pivots in bearings 8 and

10. Bearing 8 is supported by radial blades 9 in the first intake element 1, and bearing 10 is supported in the center of a star arrangement of blades 11 for orientation of the flow, which are anchored peripherally to the casing of the device, which is described below. Advantageously, similar orientation blades 12 are arranged in the opening of tubular element 2, which they mechanically connect with coaxial intake element 1.

Arranged downstream from blades 11 is afterburning chamber 14, in the anterior part of which burner 15 is installed. The latter is made up of a substantially spheroidal hollow body made of stamped stainless steel sheet in the form of two shells which extend laterally in order to form blades 16 used for supporting burner 15. Starting from blades 11, the internal wall of the casing of the device forms convergent section 13 which connects the general intake section of the device to the smaller section of passage available in afterburning chamber 14 around burner 15.

Formed in the anterior part of burner 15 are openings 17, through which a part of the stream which sweeps the burner can penetrate into the latter. Mounted in the posterior part of the burner are thermal elements 18, in the present case in the form of ceramic glow plugs containing electrical resistors planned and supplied so to maintain said glow plugs at a temperature of incandescence, for example, at 600°C. The burner ends posteriorly with at least one flow opening 19, through which it opens into afterburning chamber 14. /7

Installed at the rear end of afterburning chamber 14 is a set of catalytic elements made up of disks 20 alternating with rings 21; these parts are assembled by longitudinal bolts 22, and rings 21 are supported peripherally by the casing of the device. Disks 20 and rings 21 are preferably formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy. In this material, the ratio between the exposed surface and the volume is very high, and consequently, this material is appropriate for being used as effective catalyst, and it moreover has good filtration properties. As catalyst, it acts effectively in particular on the nitrogen and sulfur compounds, and as filtering agent, it separates the powdery residues, particularly the lead oxides and sulfur compounds.

The last disk 20 carries a noise dampening component formed by tapered casing 23 made of perforated sheet metal, in which spiral metallic leaf spring 24, also run through by perforations, is wound with its turns spaced out. This structure forms a number of communicating chambers, substantially open in the direction of the flow, which exert an effective action of attenuation of the vibrations and consequently of the noise without offering appreciable resistance to the gas flow.

The device ends with a flow opening which, in the example represented, is delimited by two channel elements 25 and 26, fitted in one another, articulated anteriorly at 27 to the casing of the device and pushed towards one another by leaf springs 28. Elements 25 and 26 can be

moved, when the force of leaf springs 28 is overcome, to a position indicated by a dotted line in Figure 1, in that case increasing the cross section of flow of the device.

Passages 29 can be provided in order to allow the ambient air to proceed to sweep /8
channel elements 25 and 26, flowing posteriorly around the flow of exhaust gases leaving these channel elements. This flow of air also acts towards a useful cooling of springs 28.

The casing of the device, which encloses all the components described up to now, is formed substantially by two stamped sheet metal shells, one lower 30 and the other upper 31, joined along a horizontal axial plane and connected to one another by rims 32. This arrangement allows very easy mounting of the whole structure, and rims 32 also ensure the connection of certain internal parts, such as blades 16 of burner 15. If considered by the way, certain parts of one of the shells can be made removable, by replacing rim sections with connections using bolts, in order to allow access to the mobile internal parts, such as fan 7 and channel elements 25 and 26, or to other parts whose replacement can be foreseen. The shells of the casing are double walled, and acoustically and thermally insulating materials 33 are arranged between the external wall and the internal wall. In the site of afterburning chamber 14, which represents a source of heat, it is possible also to provide exterior wall 34 surrounding casing 30-31 a certain distance away from it in order to guide the air to sweep the casing and to cool it effectively.

The functioning of the device which has been described is the following. The exhaust gases coming from the engine go from exhaust pipe 0 to tubular intake 1 and act on fan 7 making it turn and consequently giving rise to the suction of a stream of additional air from intake 2 through nonreturn valve 3-5. The two streams proceed together, oriented by blades 11, but at least partially separated by a stratification, with hotter layers formed mainly by exhaust gases inside, and with cooler layers formed mainly by additional air on the outside. These gases arrive /9
at afterburning chamber 14 and sweep burner 15. A part of the exhaust gases penetrates into burner 15 through openings 17 and, under the thermal action and photochemical effect of glow plugs 18 heated to red hot, undergoes endothermic dissociation involving carbon dioxide in particular; and then it flows through opening 19, mixing according to arrows A with the rest of the exhaust gases and with the additional air present in afterburning chamber 14. In the mixture thus formed, an exothermic recombination occurs, particularly of the carbon dioxide, in the form of a very hot flame which propagates, to the whole mixture which is present, a reaction leading to almost complete combustion, of the unburned substances and of the carbon monoxide which are present with the help of the additional air.

The hot mixture, now for the most part cleaned, then comes in to contact with catalytic elements 20 and 21, passing between them and partially through them, and there it is subjected to a catalytic cracking action which decomposes the last residues of unburned substances, to a catalytic oxidation action involving the possible residues of carbon monoxide, to a catalytic

action decomposing the nitrogen oxides and transforming them into noncontaminating elements, and to a chemical action which transforms the sulfur compounds into solid powdery substances. The set of disks 20 and rings 21 at the same time constitutes a reducer of powdery materials, which functions either partially by filtration, due to the permeability of the catalytic elements, or by deflection of the flow; in this way, the elimination of the gases is obtained, particularly that of the lead oxides derived from the combustion of the anti-knock substances possibly contained in the fuel which is used, and of the powdery sulfur compounds. Furthermore, the passage through catalytic elements 20 and 21 also gives rise to extensive attenuation of the noise of the gases; this noise is finally attenuated later by spirally wound perforated metallic leaf 24, which gives rise to this attenuation without appreciable dispersion of energy. /10

Finally, the gases leave through channel elements 25 and 26. Springs 28 are planned so as to balance the pressure exerted by the exhaust gases on channel elements 25 and 26 under medium operating conditions. At higher speeds, this pressure increases and brings about a mutual moving apart of channel elements 25 and 26, thus increasing the flow cross section rather than the speed of the gases, and therefore advantageously reducing the exhaust back pressure.

When passages 29 are provided, a laminar flow of air runs around the main flow of the exhaust gases, thus forming a sort of cushion between the exhaust gases and the ambient air, with the result of reducing the turbulences, resistances and noise, and of advantageously cooling the mobile parts of the flow adaptor.

In effect, the phenomena briefly described do not take place continuously but in a number of operating states, inside the device, a dynamic working state of pressure oscillations is established which propagates alternately in both longitudinal directions; the function of nonreturn valve 3-5 is precisely that of deflecting the pressure waves when they come from the interior, preventing their back flow and promoting the establishment of said dynamic working state of pressure oscillations, similar to that of a pulse jet.

By virtue of the characteristics and behaviors which have been described, the device according to the invention makes it possible to effectively clean exhaust gases, with elimination of the contaminating substances which they contain, and at the same time, to effectively attenuate the vibrations and consequently the noise. As a result, the device according to the invention, although it is suitable for more general applications, is particular useful for cleaning and muffling the exhaust of internal combustion engines. It should be noted that, for the reasons indicated above, the device according to the invention is capable of effectively cleaning the exhaust of Diesel engines and of installations in general in which fuel oils are burned, which up to now were practically excluded from any possibility of effective cleaning. /11

A particular advantage is obtained in the application to engines of this type mounted on vehicles, because in this case, the thrust exerted by the exhaust gases flowing from the device

can be used for providing additional propulsive thrust. In this regard, it must be noted that the structure, described as being that of a muffler-cleaner capable of also providing a propulsive thrust, can also be used, if necessary, to increase the propulsive effect by opportunely injecting a flow of atomized or gaseous liquid fuel into the afterburning chamber.

Naturally, different modifications can be made on the components which have been described. Thus, for example, as thermal elements in the burner in the burner, instead of ceramic glow plugs, it is possible to use other types of special electrical resistors, or either elements in the shape of a bar or other shape, heated by induction. The body of the burner can be produced of materials other than stainless steel, for example and advantageously, of quartz. Instead of the channel elements which were described, the flow adaptor can have other variable surface area arrangements, for example, a system with multiple lamellae similar to that used in the exhaust of propulsion turbojets.

Claims

1. An exhaust muffler-cleaner, particularly for internal combustion engines, of the type in which the exhaust gases not only are regularized in their flow conditions in order to reduce noise but are also subjected to afterburning for the purpose of eliminating their unburned parts, and to catalytic action aiming to eliminate the harmful substances, characterized by the fact that it mainly includes first intake (1) for the exhaust gases to be treated, second intake (2) with nonreturn valves (3-5) for additional air, said second intake (2) being arranged in the form of a ring around first intake (1), axial suction fan (7) arranged so as to act with its central portion in association with said first intake (1), and with its peripheral portion in association with said second intake (2), afterburning chamber (14) arranged so as to receive the confluence of the flows coming from said first and second intakes (1, 2), a burner arranged in said afterburning chamber, said burner being in the form of hollow (15) body with intake (17) and outlet (19) openings and containing thermal elements (18) electrically heated to the temperature of light emission, a set of catalytic elements (20, 21) arranged downstream from said afterburning chamber (14), and flow adaptor (25, 26); as well as thermally and acoustically insulated casing (30, 31) whose internal walls are aerodynamically shaped so as to follow the transformations of the gases passing through the different parts of the device.

2. An exhaust muffler-cleaner according to Claim 1, intended for a vehicle, characterized by the fact that said second intake (2) is arranged so that a stagnation pressure produced by the wind from the travel of the vehicle acts on it.

3. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that suction fan (7) is planned to exert its maximum action at medium speed (such as 60% of the maximum speed) of the engine for which the device is intended. /13

4. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that series of radial blades (9, 12, 11) for orientation of the flow and for mechanical support of components are arranged in said first (1) and second (2) intakes and downstream from said fan (7).

5. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said burner (15) is in the form of a body made of stainless steel containing nickel.

6. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said burner (15) is in the form of a body made of quartz.

7. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said thermal elements (18) are in the form of ceramic glow plugs containing electrical heating resistors.

8. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said thermal elements (18) are in the form of elements heated by induction.

9. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said set (20-21) of catalytic elements is in the form of a series of disks (20) and rings (21) arranged in an alternating manner, which are formed by a permeable sintered material of hollow spheroidal globules of copper or copper alloy.

10. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that /14
installed downstream from the set (20-21) of catalytic elements is a nondissipative noise dampening component, formed by a spiral perforated metallic leaf spring.

11. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said flow adaptor (25-26) has mobile elements (25 and 26) acted upon elastically and moved by the pressure of the exiting gases.

12. An exhaust muffler-cleaner according to Claim 11, characterized by the fact that said flow adaptor (25-26) is delimited by two elements (25 and 26) mutually fitted together, applied towards one another by elastic components (28), with a pressure corresponding to the action exerted by the exhaust gases under medium operating conditions.

13. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that air passages (29) are arranged so as to guide a lamellar flow of ambient air around said flow adaptor (25-26).

14. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that said casing (30-31) of the device is mainly made up of two shells (30 and 31) juxtaposed according to an axial plane and connected together peripherally while enclosing the internal components.

15. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that certain parts of said shells (30, 31) are connected in a removable manner in order to allow access to internal components.

16. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that said /15
shells (30, 31) are double walled, and that, between the external wall and the internal wall, they enclose thermally and acoustically insulating material (33).

17. An exhaust muffler-cleaner according to Claim 14, characterized by the fact that arranged around afterburning chamber (14) is subsequent wall (34) surrounding shells (30, 31) of the casing of the device a certain distance away from them.

18. An exhaust muffler-cleaner according to Claim 1, characterized by the fact that it has a means for supplying an atomized or gaseous liquid fuel, opening into the afterburning chamber in order to produce a propulsive thrust.

European Patent Office

Application Number EP 85 20 0876

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT			Page 1
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.[4])
A	DE-A-2 163 537 (VOLKSWAGEN) * Page 6, line 7-page 8, line 31; figures 1, 2 * ---	1	F 01 N 3/24
A	US-A-2 985 255 (CLARK) * Column 2, line 29-column 3, line 52; figure 1 * ---	1	
A	DE-A-2 212 721 (SNOY) * Page 2, line 30-page 4, line 38; figures 1-3 * ---	1	
A	DE-A-2031 299 (APPCA) * Page 5, line 10-page 8, line 21; figure 1 * ---	1	
A	US-A-2 065 681 (FOGAS) * Page 1, left column, line 39-page 2, left column, line 28; figures 1-4 * ---	1	TECHNICAL FIELDS SEARCHED (Int. Cl.[4]) F 01 N
A	US-A-4 345 431 (SUZUKI) * Column 4, line 64-column 6, line 62; figures 2, 3 * ---	1	
A	DE-A-2 418 108 (UNIVERSAL OIL) * Page 7, line 1-page 9, line 19; figure 1 * ---	1	
The present search report has been drawn up for all claims.			

Place of search	Date of completion of the search	Examiner
The Hague	September 20, 1985	M. Hakhverdi

CATEGORY OF CITED DOCUMENTS

X: Particularly relevant if taken alone.
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.[4])
A	US-A-4 054 418 (MILLER) * Column 2, line 59-column 4, line 24; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.[4])
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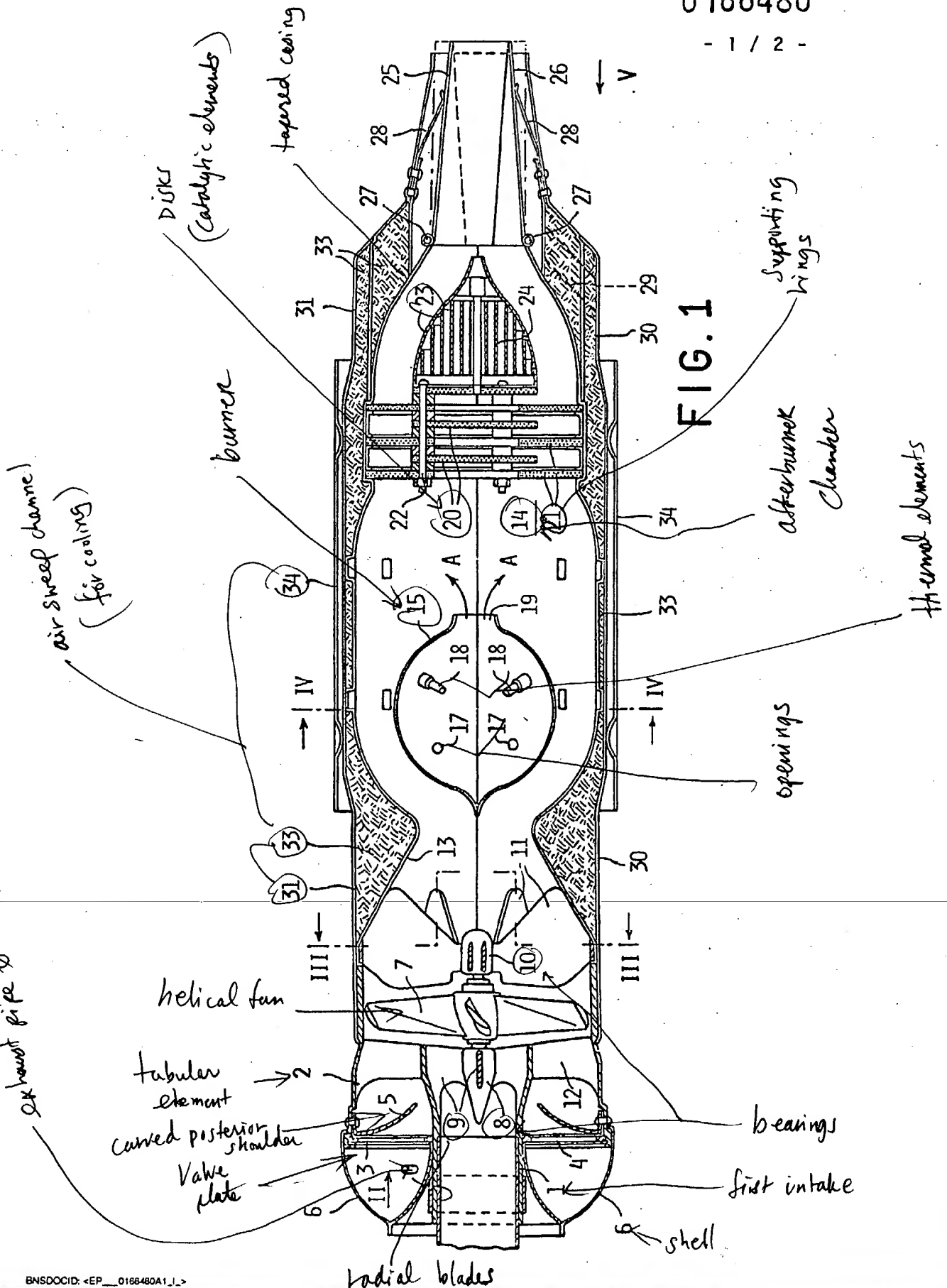

FIG. 1